

Hans Reichenbach, Causal Networks, and the Fundamental Nature of Time

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Abstract:

A review of seminal books [1] **The Philosophy of Space and Time** [1928] and [2] **The Direction of Time** [1956] by [Hans Reichenbach](#) [September 26, 1891 - April 9, 1953 (aged 61)] reveals that he was almost near a solution to the '[problem of time](#)'. His **Causal theory of Time** uses cause and effect patterns [cause and effect nets or **causal networks** as used in my papers] to define an **arrow of time** pointing from a **cause** event α [or source, e.g. excited state of an atom] generating a signal [e.g. photon] that travels to an 'effect' detector β [or sink] creating an endpoint effect and the recognition that time is a construction [or 'arrow'] pointing from α to β leading to a time defined as $T_{\alpha \text{ to } \beta}$ were pioneering concepts. His work has informed my research to get a clear theory about what time really is and what time is not.

Reichenbach primarily looks at the [Epistemology](#) of space and time in these two books but with a thorough presentation of the physics under scrutiny. Definition: Epistemology ($\text{I, } \rho\text{I} \sigma \text{t} \text{I } \text{m} \phi \text{e} \delta \text{z} \text{I}$; from Greek ἐπιστήμη, epistēmē 'knowledge', and -logy) is the branch of philosophy concerned with knowledge. Epistemologists study the nature, origin, and scope of knowledge, epistemic justification, the rationality of belief, and various related issues.

Epistemological issues are not of primary concern here. This paper is going to focus on Reichenbach's insights about time and whether or not causality and causal networks were used to explain how time is created.

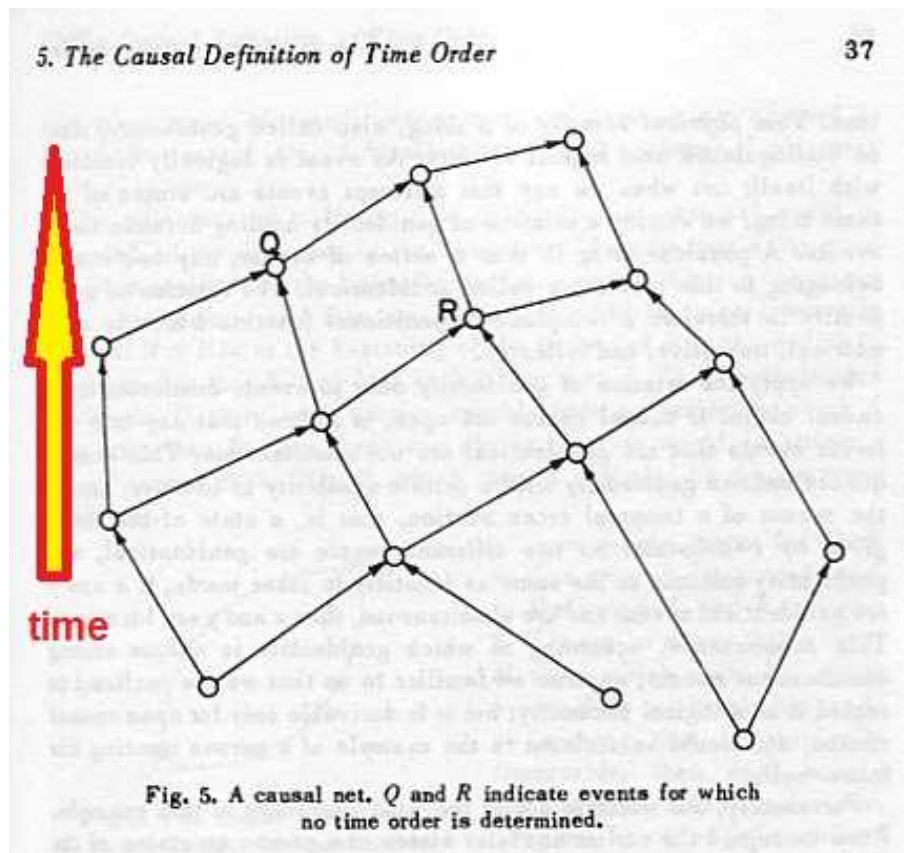
In the first book, **The Philosophy of Space and Time** [1928], he presents us with a **causal theory of time**, he notes that "time order represents the prototype of causal propagation", and "a signal sent from one place to another is a **causal chain**". He also states that "causal order that does not employ the direction of time" can be used in "our definition of time order". Therefore "the concept of the causal chain" leads us to the idea that "the order of events corresponds to the order of time".

However confusion arises from his statement that "*there are no closed causal chains*". By this he means that an event or **cause** event α leading to another event or an **effect** event β can't return to the starting point event α at an earlier time. In this regard he has confused **process reversal** with time reversal. Processes can cycle back to previous states not in time but in configuration. This constitutes a fundamental error in his identification of causal chains or nets occurring in space-time.

He later states that "An additional essential property of time is its directionality. This specific feature is based on the fact that time—and time alone—is the dimension of the causal chain ins upon which we have based our theory of space and time". At the end of this book he states "it was the concept of causal chain which proved to be the ultimate basis of the space-time order". The causal chain or causal network as I have used it was in place

in his ideas in 1927 but he diverged into trying to explain relativity without a clear picture of time created by expanding the scope of his causal theory of time. Thus he loses his way into the space-time constructs which generated time paradoxes such as time reversal.

He was aware that **cause and effect chains or nets** were the basis for developing a theory of time. He also proposed that the construction of time from causal chains or networks required specifying the **operational procedures** that define how observed events are coordinated with standard clocks to determine the time of an event.



In the second book we are looking at, *The Direction of Time*, he directly addresses the causal theory of time in section 3. He states that “time order is reducible to causal order”. He recognized the importance of signals [e.g. photons] linking up events in causal chains. He didn’t however see that the signals are the simplest form of an **arrow of time** and that **signals carry information** content about the state of the source as well as the sink or detector when observed with respect to a standard clock [e.g. atomic clock] or more importantly the **‘registering’ instrument** of our brain, the **T-computer**. In the figure above there is a hidden assumption about a time ‘dimension’ pointing from bottom to top. This is the kind of *petitio principii* fallacy that has propagated myths about time reversal. We see this again with Feynman’s “Theory of Positrons” [1949].

The three figures below are based on illustrations from ‘*The Direction of Time*’ and show how one can correct the time reversal error Feynman made using conventional space-time diagrams by converting them into causal networks or cause and effect graphs in the vacuum without direct reference to any arrow of time or an assumed time direction. Time is created from information carried by signal or particles using their observable velocities of and the spatial locations of their initial and final positions as observed independently.

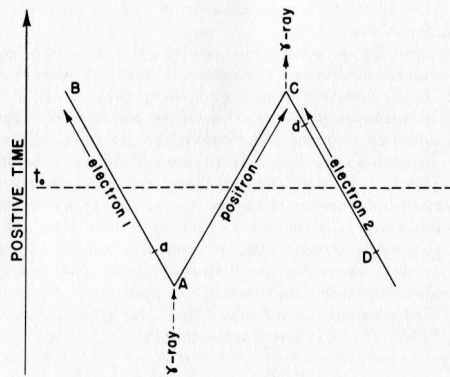


Fig. 38. Pair production and pair annihilation in a Wilson cloud chamber.

Conceptions of this kind were developed by E. C. G. Stückelberg and R. P. Feynman.¹ Their investigations showed that a positron—that is, a particle of the mass of an electron, but carrying a positive unit charge—can be regarded as an electron moving backward in time. The negative unit charge of the electron, which travels in the opposite time direction, has the same physical effects as the charge of the positron traveling forward in time; and therefore the two interpretations cannot be distinguished observationally.

Feynman showed that these conceptions can be used for an explanation of pair production and pair annihilation. It has been observed on photographs taken in a Wilson cloud chamber that, upon incidence of a γ -ray, an electron and a positron are generated from “nothing” and, starting from the same point, travel along different paths. The positron is usually not long-lived; it encounters some other electron traveling free through space and then merges with it in an act of collision. These two particles thus vanish completely, leaving as their effect

¹See E. C. G. Stückelberg, “Remarque à propos de la création de paires de particules en théorie de relativité”, *Helv. phys. Acta*, Vol. 14 (1941), pp. 588-594; and “La mécanique du point matériel en théorie de relativité et en théorie des quanta”, *ibid.*, Vol. 15 (1942), pp. 23-37. Also see R. P. Feynman, “The Theory of Positrons”, *Phys. Rev.*, Vol. 76 (1949), pp. 749-759.

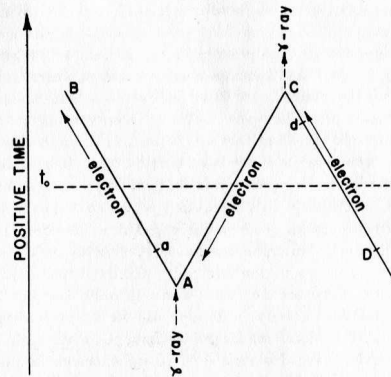


Fig. 39. The process of figure 38 regarded as the world line of a single electron, which from C to A travels backward in time.

only a new γ -ray starting from the point of collision. Figure 38 may illustrate these processes. Positive time is represented by a vertical line going upward; the other solid lines represent world lines of particles. Dotted lines indicate the world lines of the γ -rays. In the event A, the incident γ -ray produces a pair consisting of electron number 1 and a positron. In the event C, the positron collides with electron number 2; this pair is annihilated in the collision, the only trace being the γ -ray starting at C. In the photograph, the paths of the particles are visible and show a spatial arrangement similar to that of the solid lines in the diagram; the γ -rays are not visible in the photograph.

According to Feynman, we can as well interpret the process diagrammed in figure 38 by regarding the train of lines DCAB as the world line of one single electron, which from C to A travels backward in time, as indicated in figure 39. Instead of three particles, we thus have only one. This interpretation has the advantage that we need not speak of pair production and pair annihilation; the one particle is there all the time. The causal anomalies of creation from nothing and vanishing into nothing are thus eliminated; however, in exchange for them another causal anomaly enters the description: the electron travels part of its path backward in time.

We meet here with a new illustration of the theory of equivalent

STEP 1 : REMOVE TIME FROM SPACE-TIME LEAVING JUST SPACE

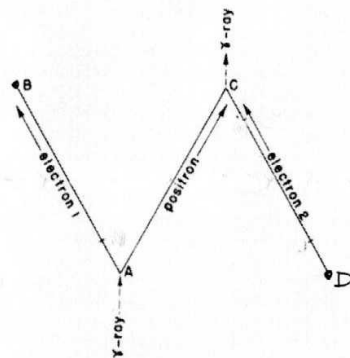


Fig. 38. Pair production and pair annihilation in a Wilson cloud chamber.

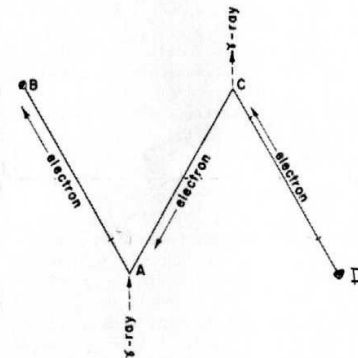


Fig. 39. The process of figure 38 regarded as the world line of a single electron, which from C to A travels backward in time.

STEP 2: CONVERT TO CAUSAL NETWORKS

A, B, C, D ARE NODES OF NETWORKS FIXED IN SPACE

$$\text{LET } d \equiv d_{AB} = d_{AC} = d_{DC} \quad \text{LET } v = v_{AB} = v_{AC} = v_{DC} = v_{CA}$$

• THEN WE DERIVE TRANSIT TIMES BETWEEN NODES:

$$t_{AB} = t_{AC} = t_{DC} = \boxed{t} = t_{AB} = t_{CA} = t_{DC} = \boxed{\frac{d}{v}}$$

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The Time of Quantum Physics

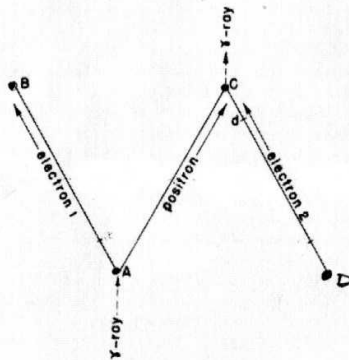


Fig. 38. Pair production and pair annihilation in a Wilson cloud chamber.

30. Particles Traveling Backward in Time

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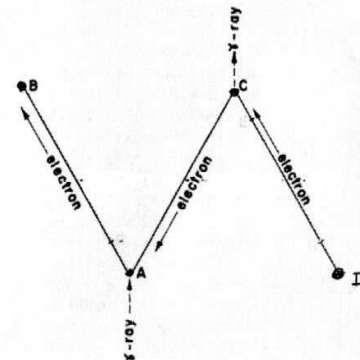


Fig. 39. The process of figure 38 regarded as the world line of a single electron, which from C to A travels backward in time.

NOTE THAT THE POSITRON (FIG. 38) IS MOVING FROM A TO C IN SPACE ONLY IN A DIRECTION OPPOSITE TO THE ELECTRON (FIG. 39) FROM C TO A. WITHOUT TIME CONFUSING THE DIAGRAMS, THE TIME REVERSAL INTERPRETATION IS NOT NEEDED. TIME IS A DERIVED CONCEPT, NOT FUNDAMENTAL LIKE SPACE.

He spent a great deal of the book looking at concepts that are in fact secondary considerations with respect to seeking the fundamental nature of time. These include; thermodynamics, entropy, statistics of ensembles, probability and reversibility, information theory and quantum mechanics. Once again he missed the point that the structure of time is best explained by starting with his causal chains and developing causal lattices or networks and recognizing that space-time is a map and not the territory of time...only a visualization that is misleading as I will explain.

What time is and what time is not:

First a review of the 7 principles I have found that define the foundations of time *not* as a *dimension* but as *information* used to construct maps [causal networks] of observed changes in the configurations of matter in the universe found to be the *actual nature of time*.

1. **Philosophy of Time:** time exists as information, NOT as a dimension. Time is as real as information is real. Process reversal is not time reversal.

2. **Arrows of Time: Quantum Arrows of Time [QATs]** and all other arrows of time only exist as constructions from signal/information flow in causal networks. All arrows of time point from cause [source] to effect [sink] from simple 2-level systems at the quantum scale such as photon emission in atoms up through the cosmological domain through hierarchical scaling of interconnected causal networks at various plateaus of complexity [POCs].

3. **Direction of Time:** only exists as directions associated with vectors representing arrows of time pointing from cause to effect [source to sink] in the [causal networks](#) of the evolving universe.

4. **There is no Time to travel 'in', only space [i.e. the vacuum]** where the 'now' created by our consciousness is all we can directly experience. Note that the vacuum exists as a physical entity and space is only a map of this fundamental basis for the universe. [“The Map is not the territory”](#) - [Alfred Korzybski](#)

5. **Our brains T-computer creates ‘time’ labeled maps of the patterns of observed changes in the configurations of matter in the universe into sequential time stamped and labeled memories.** Change is a Fundamental property of the universe, time is not. No change means no time.

- **See the following paper at: T-computers and the Origins of Time in the Brain**

6. **The Problem of Time** therefore has been solved using [Feynman Clocks](#), [T-computers](#), and [Causal Networks](#).

7. **The Vacuum is space and Time is a measure of Changes in the configurations of matter floating on the surface of the vacuum.** We attribute dimensions to the vacuum [space] as part of our application of geometry [models] to the real world. The vacuum is much more complex than mere ‘empty’ space. The vacuum is in fact a multi-vacuum with properties that depend locally on matter and globally on cosmic universality. Cosmological evolution is measured by the maps of change we construct using time as a metric.

Note: the speed of light is a fundamental property of the multi-vacuum ‘surface’ of the deep energy sea that contains the missing mass and dark energy of the universe. This is why it can’t be violated by mythical particles such as [tachyons](#) or space-time fabrications and fantasies such as cosmic tunnels or [wormholes](#).

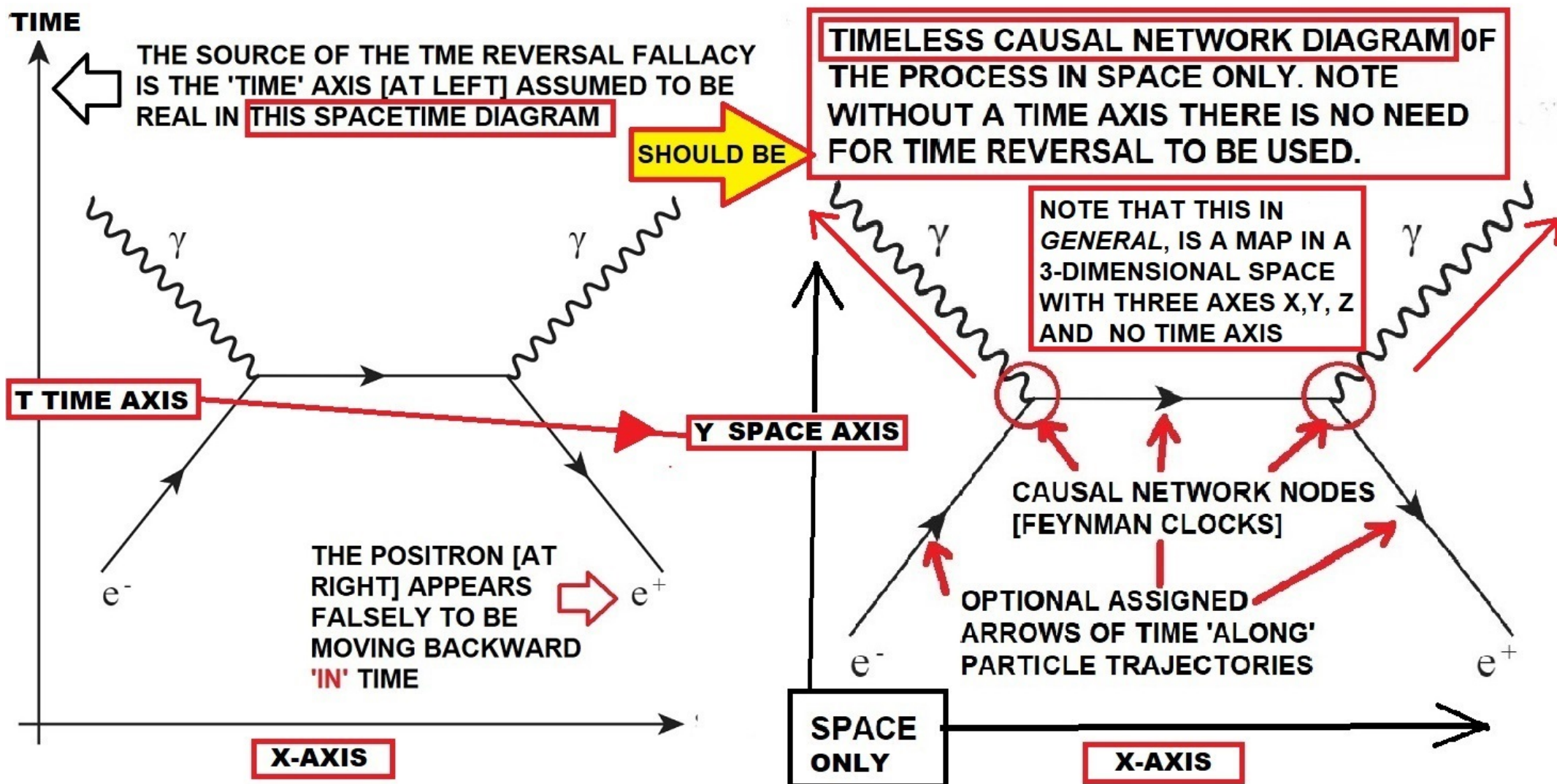
See the following for a discussion of why space-time diagrams are wrong especially when looking at time as a fundamental property of the universe:

- **Article: “The Theory of Positrons” Phys. Rev. 76, 749 – Published 15 September 1949 is shown to be wrong concerning time reversal by Scott Matheson Hitchcock**
- **The PDF full version of Feynman's original paper* is at:**
<https://authors.library.caltech.edu/3520/1/FEYpr49b.pdf>

Special Note: Time is still useful as a measure of change in our daily lives. Using repeating reproducible regular signal generating systems such as standard clocks [e.g. atomic clocks, watches, computer clocks etc.] gives us a way to create our ordered time maps. Time produced by comparison of a standard clock with the observed system and processed by our brains T-computer or similar ‘clocked’ information processing devices is ‘real’. The reality of time as a pacer of human activities is embedded in our lives.

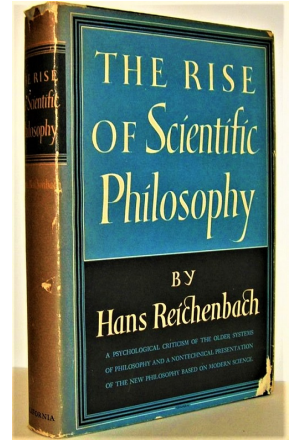
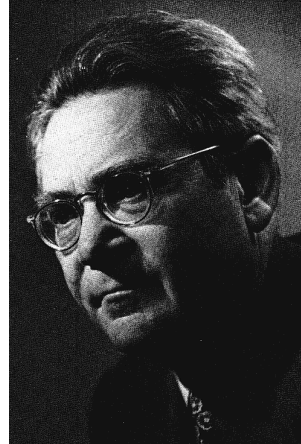
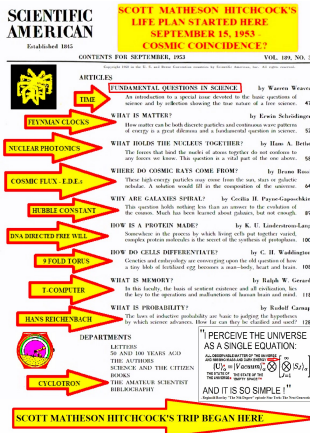
Conclusions:

Reichenbach's two books listed here are a great primers for looking at the scientific approach to time in spite of the diversions of epistemological inquiries and immersion into relativity. While he was ‘almost there’ with the causal theory of time, his insights are worth close examination. My causal network theory clearly has roots in his pioneering work. The addition of the T-computer and its confirmation by fMRI brain studies along with recognition that if one gets rid of space-time models and uses causal networks to create time as a measure of change allows us to get closer to an understanding of the true nature of time.



WHY Feynman's Positron Time Reversal Proposal in 1949 is WRONG AND THE TIME REVERSAL & TRAVEL MYTHS are *FINALLY CLEARED UP* by SCOTT MATHESON HITCHCOCKS THEORY OF TIME

159 Days



Ψ₁► It has been my great and very special **purpose** to have **possibly** completed one of the primary intellectual missions of **HANS REICHENBACH** namely his pursuit of the fundamental nature of **TIME** and its scientifically correct and transparent philosophical representation in our body of knowledge.

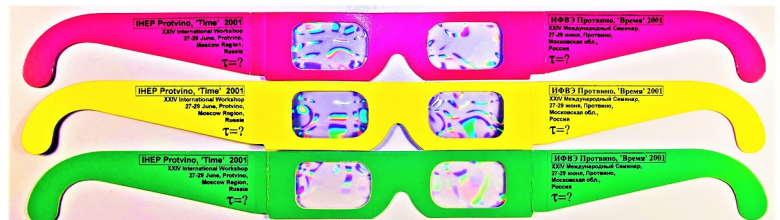
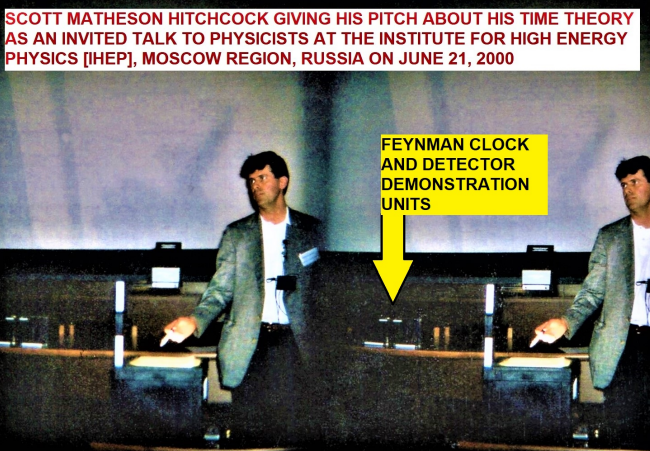
Ψ₂► **A MAGICAL THINKING EXCURSION**: This honor appears to have been given to me **159 days** [at about 4 months in the womb] before my birth at his death in some sort of **signal transmission** from him and reception by me **through the vacuum medium** acting like a **transfer** of some **portion** or **aspect** of his 'soul' or 'spirit' [both concepts stinking of illogical religious superstition] via a **long distance synchronized DNA resonance or other unknown cosmic process** between us?

Ψ₃► I would guess **soul** and **spirit** concepts were repulsive to him by their non-scientific nature. The **meaning** of all this seems to be keeping his spirit alive in my brain in order to finish his life work on this subject which was cut short by his premature death.

Ψ₄► So, in this fantasy I put a special meaning and purpose in my world. It is my **feeling** that this is more than mere **temporal coincidence** of course this is **magical thinking on my part** - **a fun and colorful indulgence in my old age!**

→ **SCOTT MATHESON HITCHCOCK** 2024

JUST LOOK AT THE AMAZING RESULTS



$$\tau_{SFC} \equiv \frac{\hbar}{\Gamma_{FC}} = \frac{\hbar}{|\langle 1, E_0 | H_{E^* \rightarrow E_0} | 0, E^* \rangle|^2} = \frac{\hbar}{I_R}$$

$$\tau_{GUTs} = \alpha\tau_{\text{strong}} = \beta\tau_{\text{weak}} = \delta\tau_{\text{electromagnetic}} = \epsilon\tau_{\text{gravity}}$$

MAN AND TIME

J.B. PRIESTLEY

IN THIS LAVISHLY ILLUSTRATED BOOK, ONE OF ENGLAND'S
GREAT WRITERS REVEALS WHAT HE HAS LEARNED ABOUT THE
RIDDLE THAT HAS PLAGUED MANKIND THROUGH THE CENTURIES.



In order to see famous hills and rivers, one must have also predestined luck; unless the appointed time has come, one has no time to see them even though they are situated within a dozen miles.

*For everything that exists and not one sigh nor smile
nor tear,
One hair nor particle of dust, not one can pass away.*

There are optical illusions in time as well as in space.

Eternity both enfoldeth and unfoldeth succession.

Do but suppose a man to know himself, that he comes into this world on no other errand but to arise out of the vanity of time.

Think that you are not yet begotten, think that you are in the womb, that you are young, that you are old, that you are dead, that you are in the world beyond the grave, grasp all that in your thought at once, all times and places.

And the authors, not in the order above, are Blake, Chang Ch'ao, Cowley, some Anon. in *Hermetica*, William Law, Nicolas of Cusa, Proust, and Ruskin.

Change itself, however, does not give us Time. Suppose we found ourselves in a mad world, created by a surrealist demiurge. A sun like ours rises and sets and there is darkness; then three blue suns follow one another across the sky; then there is a lot of darkness, finally dispelled by a colossal double sun that glares and glares at us until we are sick of it; then a twilight into which six multicolored moons arise; and so it goes on, the scene forever changing, without repetition or rhythm. Even in such a world, of course, somebody could say, "We met when there were those three blue suns, remember?" so that some faint notion of time would be struggling through. But it would be a very dim and distorted notion, not our Time at all.

For Time as we know it, we need both change and not-change, some things moving and others apparently keeping still, the stream flowing and its banks motionless. This may seem a too obvious point to make. I do not think it is, chiefly because, in wider fields of speculation, the point has often seemed to me to have been completely missed. One philosopher tells me that all is flux, nothing remaining the same. But how can he know this? If everything is changing, including himself, how can he know that anything is changing? There could be no standard of comparison, no point of reference. → NOT SO

Similarly, if another philosopher tells me that when he examines his mind and finds there nothing fixed, only an endless flicker of thought and feeling, he seems to me to be forgetting that, unless the searching and reporting self is steadier and more reliable than any flicker or flux, his report is useless anyhow.

② Time cannot be reduced to mere change. It is true that without change in some form or other, there would be no Time. This has been denied, chiefly because a certain amount of change has been cheated into the picture. If we try to imagine ourselves in a world without sound or movement, with nothing stirring, without even our breathing or heart-beats, we must agree that we cannot have Time there. Time may not be merely something happening, but unless something is happening, there cannot be Time.

People who deny this do not completely freeze the scene; they put their living selves in it; and then of course they would be aware of Time just because something would be happening, and change, no matter on how minute a scale, would be at work. With no possibility of anything changing, within or without, Time would vanish. No change, then, no Time.

★ Time is a River without Banks, painted in the 1930s by Russian-born artist Marc Chagall. In this highly personal interpretation of the familiar concept of Time as a flowing stream, recollections from the artist's childhood—the fish, the violin, and the family clock—are set against the background of the river. On the bank, two lovers probably represent the timeless quality of love.

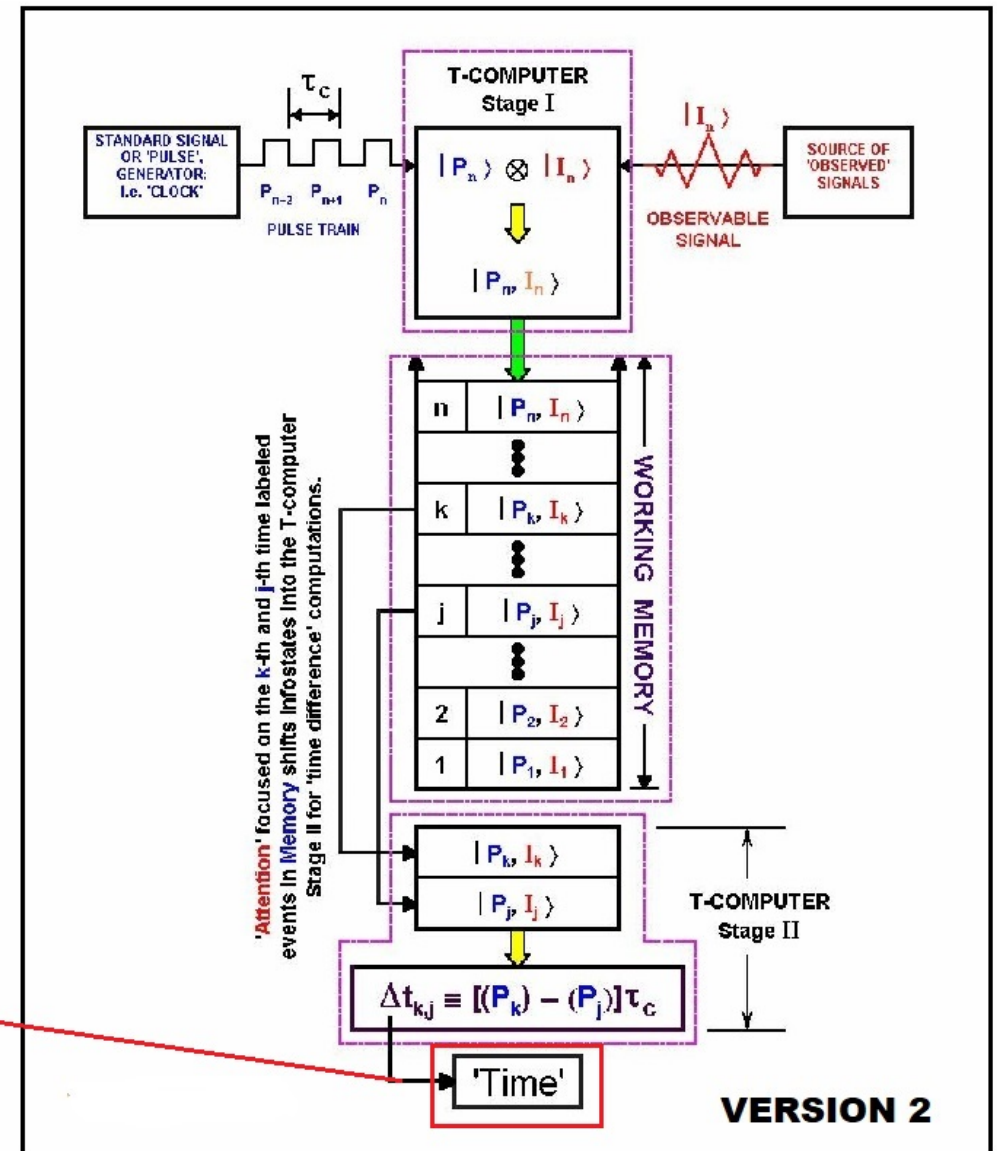
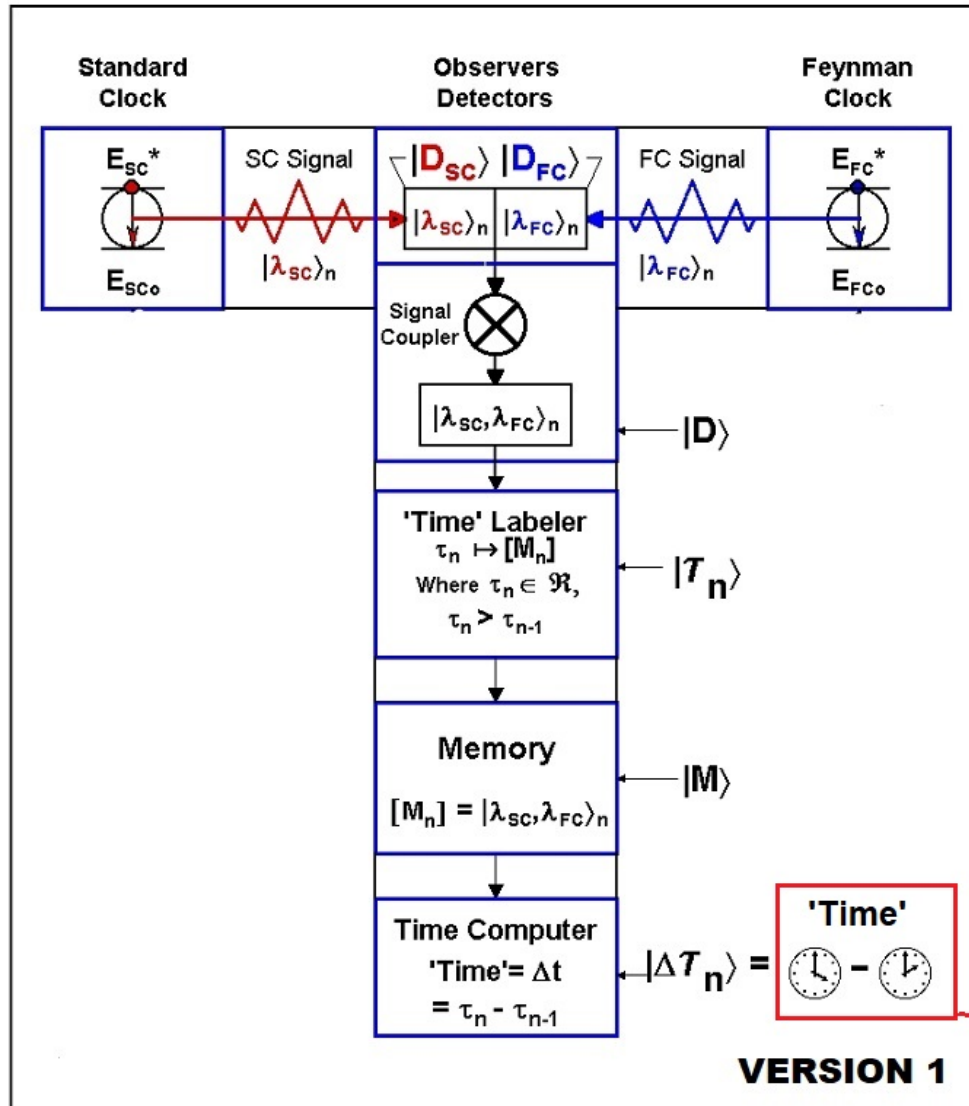
The nature of Time is found in the relationships (Functions etc) between changing systems and information flow

10/4/14

I MISSED THIS BEFORE

BUT I REALLY GOT THIS

uncredited
Origins
of Barbour's
ideas



HOW **TIME** IS CREATED/COMPUTED BY OUR BRAINS
T-COMPUTER IN THESE TOP-DOWN LOGIC DIAGRAMS